

Pacific University

CommonKnowledge

---

College of Optometry

Theses, Dissertations and Capstone Projects

---

4-1996

## The relationship between visual dysfunction and reading disability: The results of a study comparing Oregon Title One Program readers to grade-level reading peers

John P. Lowery  
*Pacific University*

### Recommended Citation

Lowery, John P., "The relationship between visual dysfunction and reading disability: The results of a study comparing Oregon Title One Program readers to grade-level reading peers" (1996). *College of Optometry*. 47.

<https://commons.pacificu.edu/opt/47>

This Thesis is brought to you for free and open access by the Theses, Dissertations and Capstone Projects at CommonKnowledge. It has been accepted for inclusion in College of Optometry by an authorized administrator of CommonKnowledge. For more information, please contact [CommonKnowledge@pacificu.edu](mailto:CommonKnowledge@pacificu.edu).

---

# **The relationship between visual dysfunction and reading disability: The results of a study comparing Oregon Title One Program readers to grade-level reading peers**

## **Abstract**

The relationship between visual dysfunction and reading disability: The results of a study comparing Oregon Title One Program readers to grade-level reading peers

## **Degree Type**

Thesis

## **Degree Name**

Master of Science in Vision Science

## **Committee Chair**

Anita McClain

## **Subject Categories**

Optometry

### Copyright and terms of use

If you have downloaded this document directly from the web or from CommonKnowledge, see the "Rights" section on the previous page for the terms of use.

**If you have received this document through an interlibrary loan/document delivery service, the following terms of use apply:**

Copyright in this work is held by the author(s). You may download or print any portion of this document for personal use only, or for any use that is allowed by fair use (Title 17, §107 U.S.C.). Except for personal or fair use, you or your borrowing library may not reproduce, remix, republish, post, transmit, or distribute this document, or any portion thereof, without the permission of the copyright owner. [Note: If this document is licensed under a Creative Commons license (see "Rights" on the previous page) which allows broader usage rights, your use is governed by the terms of that license.]

Inquiries regarding further use of these materials should be addressed to: CommonKnowledge Rights, Pacific University Library, 2043 College Way, Forest Grove, OR 97116, (503) 352-7209. Email inquiries may be directed to: [copyright@pacificu.edu](mailto:copyright@pacificu.edu)

# The Relationship Between Visual Dysfunction and Reading Disability: The Results of a Study Comparing Oregon Title One Program Readers to Grade -Level Reading Peers

by John P. Lowery, O.D.

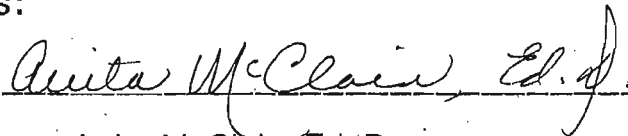
PACIFIC UNIVERSITY LIBRARY  
FOREST GROVE, OREGON

Thesis submitted in partial fulfillment of the Masters of  
Education, Visual Function in Learning Degree

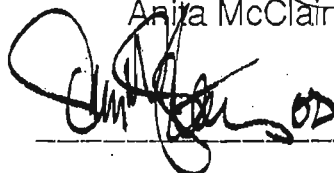
Pacific University College of Optometry and College of Arts  
and Sciences, Department of Education

April 1996

Primary Advisors:



Anita McClain, Ed. D.



Willard Bleything, O.D., M. S.

## Abstract

A comprehensive visual evaluation was given to 43 Oregon Title One Program students receiving remedial reading instruction. 50 age-matched peers reading at or above grade level served as controls. The findings were analyzed for disorders of binocularity, accommodation, and oculomotor control. Chi squared statistical analysis revealed a significantly greater incidence of accommodative insufficiency, accommodative infacility, convergence insufficiency, and saccadic eye movement deficiency in the Title One group. The results indicate that visual dysfunction is a significant contributing factor in the low reading achievement of many Title One readers. The results bring forth important implications for addressing vision in the education of reading disabled students in general.

Key Words: Visual Dysfunction, Reading Disability, Title One Program, At Risk Students

## INTRODUCTION

The relationship between reading achievement and vision has been the subject of considerable research in this century. Vision is, after all, the primary sensory system utilized in the reading process. We have come to realize through the course of this research on reading and vision, that there are many factors that can contribute to delayed acquisition and mastery of reading skills. Vision is just one of the variables that can affect the reading process and, even within the broad sensory, motor, and perceptual systems that constitute vision, there are many variables to be teased out. Reading has clearly been shown to require adequate near visual acuity provided by normal optical physiology or appropriate correction of refractive error.<sup>1,2,3</sup> There is also considerable evidence indicating that reading is facilitated by stable binocularity,<sup>1,3,4</sup> accurate and efficient oculomotor control,<sup>3,5,6,7</sup> adequate accommodative skills,<sup>3,8,9</sup> and normally developed visual perceptual skills.<sup>3,10,11</sup> All these visual processes, in a dysfunctional state, have been implicated in reading disability. Many studies have also shown that correction of visual problems improves reading ability.<sup>12,13,14,15,16,17</sup> It is the degree to which dysfunctions of the visual system contribute to reading disability that still remains a largely unanswered and controversial question. Much of this controversy arises due to the differences in professional viewpoint.<sup>18</sup> Ophthalmological literature on the subject has held fast to the view that there is very little relationship between vision and reading.<sup>19,20</sup> Interestingly, there are a number of studies in the ophthalmological literature that strongly indicate a link between visual skills and reading ability.<sup>14,21,22,23,24,25</sup> The hundreds of optometric, neuropsychological and educational studies on the subject have revealed a complex relationship that does not break down easily to the discrete categories that the medical community likes to work with. Yet clinicians still need some ground rules that will help them to identify when visual problems are likely to be contributing to reading problems. For those professionals who wish to take on these cases, successful treatment requires clear diagnoses.

Most of the research to date looking at visual factors and reading has taken the specific variable approach and there is now sufficient data, albeit confusing, on the relationship of various subsystems of vision and reading.<sup>1,3</sup> Very few studies have attempted to group findings into diagnostic categories.<sup>1,3,26,27,28,29,30</sup> The purpose of the present study is to look at the process of vision in a more holistic manner using specific case history and standard optometric tests applicable to any practice setting. If eye care clinicians and vision researchers are going to claim that dysfunctional vision plays a significant role in the manifestation of reading disability, then we need to look at the entire process from a clinical point

of view. We need to be able to relate concrete ICD-9 visual diagnoses like convergence insufficiency, oculomotor dysfunction, and accommodative insufficiency to the reading process in order to build a model for optometric management of these entities within our evolving (or devolving) health care system. In order to achieve this goal, it was necessary to exclude the specific elements of visual perception from this study as many primary eye care practitioners do not have the knowledge and assessment materials to adequately test visual perceptual skills. Unfortunately, most visual perceptual disorders are not universally accepted medical entities with reimbursable ICD-9 codes. Therefore, this study concerns itself with visual input as the first step in the reading process. The elements of visual input that are routinely tested in optometric and even, some ophthalmological settings are: visual acuity, refractive error, binocularity, accommodation, and eye movements (and indirectly, parallel pathway processing deficits). Let us look at each of these areas in terms of their impact on the reading process in order to build a case that justifies this project.

#### **ACUITY:**

Visual acuity at nearpoint is the most obvious visual function to assess when determining whether vision is adversely affecting the reading process. Visual acuity deficits are the primary manner in which visual disability is defined by law. A child is considered visually impaired and is eligible for special services in the state of Oregon if their best corrected acuity is 20/70 or less. Children whose best corrected acuity is 20/200 or less are legally blind.

Research has shown that there is a large segment of the student population functioning with a nearpoint acuity somewhat less than the optimal 20/20.<sup>23,31</sup> There have been good, controlled studies comparing nearpoint acuity between normal and poor readers that show a clear correlation between decreased functional acuity and low reading achievement.<sup>2</sup> Spache et al.<sup>32</sup> also found significantly more subjects with differences between right and left eye nearpoint acuity in their reading disabled group. Surprisingly, the bulk of the studies comparing acuity between good and poor readers measured distance acuity only.<sup>2</sup> Regardless, acuity as a stand alone finding is an inadequate measure of nearpoint visual function. It is the causative factors involved in decreased acuity and the other visual disturbances that accompany decreased acuity that are more clinically relevant.

#### **REFRACTIVE ERROR**

Intuitively, we expect that high refractive errors that cause significant nearpoint blur will hinder any nearpoint activity, especially sustained reading. The observant eye care practitioner who routinely sees learning disabled patients will likely note that there is a higher prevalence of significant hyperopia (>2.00 diopters) in the learning disabled population.

---

Research appears to support this observation.<sup>1</sup> In their 1986 literature review on the relationship between refractive error and reading ability, Grisham and Simons<sup>2</sup> found the following:

- no relationship between myopia and reading disability
- the evidence relating astigmatism to reading performance is poor
- hyperopia and anisometropia are more prevalent in reading disabled
- hyperopes tend to make slower gains in reading than emmetropes and myopes over time
- correction of hyperopia or anisometropia seems to result in improved reading performance

It is not surprising that hyperopia is related to low reading achievement. Although children can overcome even high amounts of hyperopia (>3.00 D) due to robust accommodative systems, it takes considerable effort to maintain an accurate focus. This effort not only creates asthenopia, but is distracting to cognitive processing. High accommodative input also drives the convergence posture inward creating an esophoric or esotropic binocular posture. Those who cannot overcome hyperopia accommodatively, suffer from poor acuity. Anisometropia, which also seems to be more common in the reading disabled, may decrease visual input by causing accommodative imbalance, fusional difficulties, or simply poor acuity.

#### **BINOCULARITY:**

Typical measures of binocularity include phorias, vergence ranges, stereopsis, and fixation disparity. Much of the study of binocularity has focused on phoria as a key indicator of binocular imbalance.<sup>1,3</sup> This is certainly sound reasoning from the standpoint of ocular physiology. Phoria is also relatively easy to measure by a number of dissociation methods. Some of the earliest research on binocular vision anomalies and reading was performed by Eames.<sup>21,22,33</sup> In a number of studies comparing groups of poor readers to controls, he found the reading disabled population to exhibit higher degrees of exophoria at near, reduced convergence, and a slightly higher incidence of fusional difficulties. In an exhaustive review of the literature comparing binocular vision in high and low achieving readers, Simons and Grisham found that the bulk of the literature supports Eames' findings and there was additional evidence linking poor reading with low fusional vergence reserves, anisometropia, aniseikonia, and fixation disparity.<sup>4</sup> They also found a weak positive correlation relating lower reading achievement to esophoria at near and mixed results of studies looking at stereopsis. There are also a number of studies that show little or no correlation between reading and binocularity. Many of these studies used telebinocular or other stereoscopic screening devices which have been shown to be less reliable measuring devices for binocular posture.<sup>31,34</sup>

The bottom line is that there exists substantial evidence that reading disabled children are more likely to be exophoric and have reduced nearpoint convergence ability. To investigate this relationship further, Clark<sup>35</sup> studied the reading eye movements of a group of subjects exhibiting high exophoria.



He found that the exophores did not differ significantly from controls in the number of fixations per line or the number of regressions. However, the exophoric subjects tended to overconverge in moving fixation from the end of one line to the beginning of the next. This created a need for a compensating divergence to regain binocularity at the beginning of a line of print. The net result was an increased time in moving from one line to the next. Bedwell, Grant and McKeown<sup>36</sup> investigated further the significance of binocular disorders under the dynamic condition of reading. They videotaped disabled readers and control subjects sequentially fixating two objects at nearpoint and then, reading a passage well below their reading level. Several trained observers independently rated eye movements and binocularity looking at seven different variables. For six of the seven variables, the reading disabled group was rated significantly lower:

- instability of eye coordination during saccades left to right
- indecision as to controlling eye
- unequal eye movements
- both eyes tending to diverge
- one eye tending to diverge then overconverge (as found by Clark)
- compensatory head movement

It would have been interesting to see the relationship between the subjects' reading eye movements and static binocular findings that would normally be measured in a primary care exam. The present study will explore this relationship further.

Additional evidence that poor binocular vision is related to reading difficulty comes from studies that have looked at the reading level of monocular or strabismic subjects demonstrating complete suppression. Simons and Grisham reviewed studies of this kind and found good evidence that monocular readers demonstrated less disability. Stein and Fowler<sup>37</sup> examined a group of dyslexic children who exhibited high exophoria and occluded one eye of half the group. The monocular group showed greater improvement in reading performance. In a study of first second and third grade readers, Birnbaum and Birnbaum<sup>38</sup> found that a significant proportion of subjects took longer to read a short passage and made more errors under normal binocular conditions than when monocular.

The Ludlums,<sup>39</sup> in a well controlled study utilizing optometry students, showed that reading with base in prism (simulating esophoria) significantly decreases reading comprehension. This study clearly showed that a subtle binocular imbalance that does not grossly disrupt fusion can have a deleterious effect on concentration while reading.

Another clinically relevant way to correlate binocular vision problems to reading disability would be to assess the case history of reading disabled subjects for complaints of double vision, words running together, blur, or eye strain. Clinicians who commonly see fusional difficulties at nearpoint often hear these complaints. Research tends to rely only on objective findings, but the clinician must necessarily place more emphasis on subjective reports. Bedwell, Grant and McKeown<sup>36</sup> in their study

of visual control anomalies in relation to reading found a much higher percentage of reading disabled reporting diplopia in their subject population. In the present study, a short history was included to further address this relationship.

#### **ACCOMMODATION:**

Insufficiency of accommodation has long been recognized as a contributory cause of nearpoint visual loss, even in prepresbyopic individuals.<sup>8</sup> However, there are surprisingly few specific studies relating accommodation to the reading process. A few studies have concluded that accommodative disorders occur frequently in reading disabled children, but they all lacked adequate controls.<sup>3</sup> Hoffman,<sup>9</sup> in his assessment of the visual skills of 107 learning disabled children, found that 64% demonstrated accommodative difficulties (both insufficiency and excess) and 83% showed accommodative infacility. However, some of his criteria for failure were not highly selective from a clinical standpoint and the study lacked a control group. Ygge et al.,<sup>40</sup> in a well controlled study of 86 dyslexic children found no significant difference between the subjects and controls in accommodative function. The research to date relating accommodative dysfunction to reading disability remains inconclusive. This study will look at accommodative dysfunction in light of other risk factors like uncorrected hyperopia, astigmatism, anisometropia and binocular problems.

#### **EYE MOVEMENTS:**

As with binocularity and accommodation, there is some disagreement in the literature as to whether low achieving readers exhibit poorer eye movements. Most experienced clinicians who routinely test reading disabled kids would agree that poor oculomotor control is perhaps a hallmark feature of this group. Optometric research generally supports clinical observation. Reading requires adequate saccadic control to perceive written language in the appropriate sequence. It is reasonable to assume that if adequate saccadic control is not present, it will disrupt the necessary sequential input of written language and decrease comprehension.

Many studies have shown that reading disabled children exhibit poor saccadic control during the reading process.<sup>3</sup> However, the erratic saccadic behavior has been shown by many researchers to be due to a cognitive language processing deficit of the reading disabled rather than a primary motor deficit. Rosenthal,<sup>41</sup> in his comprehensive analysis of language dysfunction, relates the following. Using the oculonystagmograph (retino-corneal electrical recordings), Goldberg found that significantly deviant saccadic function occurred when a good third grade reader or a brain damaged child came to an unfamiliar word. He also found that sequential saccadic

function was restored if a third grader was helped with unfamiliar words. While Golberg's findings seem to support the view that it is a primary language deficit that determines the erratic nature of saccadic eye movements of poor readers, his study did not specifically address the saccadic motor control of reading disabled children.

Studies to isolate saccadic function from language processing in a simulated reading test have revealed some interesting results. Using a sequence of non-language stimuli and a control group of good readers, Griffin et al.<sup>5</sup> measured saccadic eye movements using a Reading Eye Camera. They found that poor readers produced a greater number of fixations and regressions per line, regardless of the perceptual content of the reading stimuli. Pavladis was able to clearly reproduce these results using LED's as stimuli.<sup>6,7</sup> Yet, other studies of this type showed no significant difference in saccadic ability between good and poor readers.<sup>3,42</sup>

In summary, there is considerable evidence that poor readers exhibit less efficient saccadic control than good readers, but how much of a contribution it plays in reading disability remains unclear. Moreover, there is still an underlying chicken vs egg dilemma. Saccadic eye movements, as with all visual skills are learned and perfected by visual-motor experience. Lack of language processing ability delays literacy. Children who are unable to read with fluency due to a language processing deficit may not develop efficient saccadic ability simply because they don't read as much and when they do read, the saccadic process is constantly interrupted. They don't get the same amount of saccadic motor practice as their fluent reading peers. The only way to look at this problem clearly is with a cohort study that would examine the saccadic eye movements of pre-school children and follow them for several years and correlate saccadic ability to reading skills over time. This, as far as I know, has not been done to date.

Another important variable that plays into reading eye movements is selective visual attention which is mediated by parallel visual input pathways. In recent years, considerable research has been devoted to the relationship between the two distinct neurophysiological pathways of the human visual system that provide simultaneous visual input about different elements of the visual environment.<sup>3</sup> The P or parvocellular pathway is primarily involved with sustained, high spatial frequency, central visual processing. During reading, the P-pathway is responsible for taking in the detailed visual information of words during fixations. The M or magnocellular pathway is sensitive to peripheral, fast moving, low spatial frequency stimuli. The M pathway may be responsible for perception of overall word shape or length and picking up the next point of fixation prior to a saccadic jump. The reading process requires sequential and precisely coordinated use of the M and P pathway as the peripheral visual information of one fixation becomes the central information of the next. Neurophysiological research methods have measured clear differences in M-pathway processing in reading disabled individuals compared to controls.<sup>43</sup> There is now considerable evidence indicating an M-pathway deficit in the

reading disabled may produce a timing problem in integrating input from the M and P pathways. This may result in overlap of visual information or loss of visual information during sequential uptake in reading. The net result of this confusion is an increase in the number and duration of fixations and eye movements appear erratic. Thus, measurements of saccadic efficiency may correlate to M-pathway integrity. Research is ongoing in this area.

Pursuit eye movements are an important measure of oculomotor control and visual attention. Selective attention to a moving stimulus during the pursuit task is maintained primarily through the magnocellular pathway. Poor tracking ability during pursuit testing may be related to M-pathway deficit.<sup>43</sup> In the present study, both smooth pursuit and saccadic eye movements were analyzed to clearly establish diagnoses of oculomotor dysfunction.

## METHODS

### **SUBJECTS:**

The population chosen for this study consists of 93 4th, 5th, and 6th graders from five elementary schools in the Northern Willamette Valley of Oregon. The 4th-6th grade levels were specifically chosen because these students have established a clear track record of reading ability through the course of several years of standard reading instruction. Multidisciplinary research in the area of reading disability has shown that children experience delayed acquisition of reading skills for a variety of reasons including preschool environment, general developmental delay, and primary language processing deficits.<sup>41,44,45</sup> By the time a child reaches fourth grade, much of these initial learning barriers have been addressed, but a visual problem that has gone undiagnosed will persist. It is logical to assume that

an oculomotor or accommodative dysfunction may increasingly hinder a child as the print size of grade level reading material gets smaller and more crowded, and there is greater demand for sustained reading tasks. Therefore, we might expect a greater proportion of reading disability to be due primarily to visual problems in older elementary grade students than in the same population of beginning readers.

For the purposes of this study, an experimental group consisting of below grade level readers was required that were clearly defined by standard educational assessment to demonstrate lower reading comprehension and fluency skills than their age-matched peers in the control group. Ideally, all subjects in the study would be evaluated for reading ability via the same assessment tool. Although there has yet to be established a standard reading assessment tool used in all schools in the state of Oregon, there is the requirement to designate a grade level of reading achievement for all students under the guidelines of the Elementary and Secondary Education Act of 1965. These reading achievement scores are used along with more subjective measures at the school level to place students in the Title One Reading Program. Short of this researcher performing his own reading assessments, using Title One Program eligibility as the primary defining characteristic for the subject group seemed a reasonable compromise. Let us look more closely at the Title One Program in order to better define our reading delayed experimental group.

Education reform in the United States in the last ten years has once again turned its focus to standards of achievement that were popular in the 1960's. This has occurred largely as a reaction to the hard facts of an educational system that has continued to produce an unacceptable percentage of young adults who cannot read and write effectively, balance a checkbook, analyze data, or are unable to participate in self or civic

government. Many see the softening of educational standards and experimentation of the 1970's as the undermining factors. The basic tenet that all students are educable to meet basic standards of achievement in core academic subjects has become a guiding principle of educational policy as outlined in Improving America's Schools Act passed by the 103rd Congress of the United States in 1994.<sup>46</sup>

"All children can master challenging content and complex problem-solving skills. Research clearly shows that children, including low-achieving children, can succeed when expectations are high and all children are given the opportunity to learn challenging material."

We look at the other leading industrialized nations of the world producing students out of their educational systems who are better equipped to survive in a world where technology is requiring a workforce of able minds rather than able bodies. We also realize that the United States is a far more diverse population of humanity than comparable industrialized nations and this diversity creates unique problems for standardized achievement in education. Education does not occur to a population, it happens in an individual human mind over many years of assimilation and growth. The challenge that has been set forth by the new reform movement is to provide an equal opportunity for education to all the young minds in America, regardless of cultural, socio-economic, linguistic, or familial background. In order to meet national education goals, we must concentrate resources to provide the most help to schools in areas with a high proportion of at risk students. This is what the Title One program is all about.

The Title One program (Helping Students to Meet High Standards) is divided into four parts:

- A. Improving Basic Programs Operated by Local Educational Agencies
- B. Even Start Family Literacy Programs
- C. Migrant Education Programs
- D. Prevention and Intervention Programs for Children and Youth Who Are Neglected, Delinquent, or At-Risk of Dropping Out

Congress has allocated to these programs an additional \$750,000,000 over baseline each fiscal year from 1996 through 1999 with the goal of bringing all students up to an equal level of basic achievement. The basis of the Title One Funds is the realization that we can't have national education standards if we have a large underserved, at risk population of students.

At the state and local level, funds are allocated based on the number of children from low income families and disadvantaged situations as defined specifically by the articles of each program.<sup>47</sup> Title One funds can be used for any academic subject area, but typically they are reserved for reading, writing, and mathematics in elementary education.

In the state of Oregon, the Chapter One remedial reading program which was designed to provide additional individualized reading instruction to low achieving readers has come under the auspices of Title One Subpart A

funding. Subsequently, the name Chapter One was dropped and students pulled out of class to receive remedial reading instruction are now known to be served by Title One. A key factor for the present study is the criteria for selection of Title One Readers in the state of Oregon. School Districts and schools receive Title One allocations based on the economic and social characteristics of their student populations, but students are selected by teachers and principals to participate in individualized reading instruction based on reading achievement. Therefore, children from wealthy, stable, English-speaking families are receiving Title One aid. However, the majority of Title One funding is going toward its target population simply because of the structure of the funding allocation.

Reading achievement in the state of Oregon is assessed by various means at this time. Title One law has left it up to the state to adopt standard assessment tools and Oregon is working toward the goal of clearly defined performance standards for reading at each grade level.<sup>46,48</sup> For example, a student who meets the standard in reading at the 5th grade benchmark:

- reads independently and comprehends reading selections appropriate to the 5th grade
- summarizes main ideas, sequences of events and important details in reading selections
- connects reading selections to personal experiences, other reading selections or the world around him
- expresses and supports opinions about the choices the author made in writing the selection
- expresses and supports opinions about the effectiveness of the reading selections

Although most low level readers could be assessed subjectively by teachers and reading specialists based on these criteria, there is still a desire to assess students by more concrete means. Therefore, methods of evaluation such as the Iowa Reading Achievement or California Achievement Test are still the standby for establishing a grade level for many Oregon students. Test scores such as these along with more subjective appraisals are what is used to place students in the Title One reading program.

Another defining aspect of the Title One reading group is the exclusion of students on Individualized Education Plans (IEP's). Children on IEP's have various cognitive, physical, and behavioral/emotional handicaps which are assumed to be the primary condition causing their learning disability. Although many of these children also have visual dysfunctions, it was not deemed appropriate to include them in this study due to the confounding variables that they would introduce. It was important for the purity of the study to select a subject group that differed significantly from the controls only in reading ability. If this study included a visual perceptual skills battery, perhaps the IEP students would be appropriate subjects.<sup>9,10,11</sup>

---

The only significant measurable difference between the experimental and control groups besides reading achievement is that the Title One group by definition contains a higher percentage of English as a Second Language (ESL) students. The study region of the Willamette Valley has a large population of Hispanic families, many of which comprise a migratory agricultural workforce. Certainly, it would have been better for the sake of a clean study to exclude the ESL students, but this was not possible to do. The data from the ESL group was analyzed separately to see if there was a significant difference between their visual skills and the rest of the experimental group.

A major concern in selecting the Title One Readers as the experimental group for this study was that there would be a significant difference between the experimental and control groups in terms of family financial condition and educational enrichment in the home. Schrier and Hamakiotes performed comprehensive visual screenings on two disparate socioeconomic populations of students.<sup>49</sup> Their study showed that children from an underprivileged area of New York City had a 38% failure rate compared to 24% failure rate of age-matched children from a private elementary school in the Greenwich Village area of the city. However, much of this difference in failure rate was due to a higher incidence of uncorrected refractive error in the underprivileged group. Basic lack of access to healthcare was indicated as a causal factor. It is possible that this kind of inequity in socioeconomic advantage exists between the two subject groups in this study, but this is unlikely due to the fact that all subjects were taken from the same socioeconomic region. Certainly there is a clear socioeconomic difference between children from schools that receive Title One aid and those that do not. However, as stated earlier, within each school with a Title One Program, students are selected for participation based on reading achievement only. Since the Title One students and controls in this study were selected to create equal numbers for each group within each participating school, the socio-economic difference between the two groups was kept to a minimum.

We know that low socio-economic level is related to lack of support in the home which in turn adversely affects reading and general academic achievement. This is the reasoning for the Title One program. Certainly, lack of enrichment and educational opportunity is a strong factor in low reading achievement. This study will determine how much of a factor poor visual skills contributes to the delineation of this group of underachieving readers in the Northern Willamette Valley of Oregon.

#### **DATA COLLECTION:**

Elementary schools in the Northern Willamette Valley were contacted and presented with the chance to participate in the study. The benefit to the children of a free visual evaluation was stressed. It was surprising to this researcher how many principals and education service directors turned down



the opportunity to receive these services for their students, especially considering that the experimental group was one already identified to be the most at risk by the state of Oregon.

All subjects were evaluated on school grounds in facilities provided. Prior to evaluations, informed consent forms were sent home from the schools on school letter head for parents to read and sign indicating approval for their child to participate in the study. A translated spanish version was used when necessary. Evaluations took approximately 25-30 minutes/student and were coordinated by the Title One and classroom teachers. Students were sent to the researcher in a random order with no prior knowledge of the students reading history. All information and data on the evaluation form was collected by the reseacher. An equal number of Title One and control students were tested at each grade level. In two of the schools with a high percentage of Hispanic students, the researcher requested that the controls be picked from the grade level readers in such a way as to approximate the ethnicity and language background of the Title One students at each grade level. IEP students were excluded from the study for reasons previously discussed. When evaluations were complete, the researcher was provided with a list of the subjects who were being served by the Title One program and the most recent grade level reading score for each as determined by standardized testing. The schools and parents were provided with a copy of the data collected on each child along with a summary report and recommendations for glasses, follow-up, etc.

Copies of the informed consent form and the evaluation form used in the study are represented in Appendix One.

## **VISUAL EVALUATION PROCEDURES:**

All procedures used in this research were standard optometric measures of visual function <sup>50</sup> with the goal to produce clinically useful data. All instrumentation and devices used are those commonly found in an optometric clinic. The evaluation was weighted toward tests of nearpoint visual function and consists of several different types of clinically proven measures of binocularity and accommodation.

Basic data on the subject including name, age, grade level, gender, ethnicity and the primary language spoken in the home was gathered. Ocular history regarding glasses and contact lens wear and history of disease injury or surgery was determined. Each student was asked if they experience blur while reading or in the distance, head or eye pain while reading or double vision while reading. Answers were placed in a categorical format of never, sometimes or always in order to create clear frequency distributions. No

---

information was asked about reading ability or special services being provided to the student.

Distance visual acuity was measured monocularly at a distance of 20 or 15 feet using the standard snellen chart. Near acuities were measured at a distance of 40 cm using a standard Snellen near point acuity card.

Unilateral and alternating cover test was performed while the subject fixated a 20/400 E in the distance and a 20/200 E at 40 cm.

Break point for Near Point of Convergence was evaluated objectively using pencil with 20/80 size letter A for a target.

Extraocular muscles were evaluated for any limitations of gaze.

Depth Perception was measured in seconds of arc at 40 cm using the circles on the Stereofly Test.

Distance refraction was measured by means of retinoscopy through a +1.50 working lens and a 20/400 E distance target.

Near Accommodative Posture was evaluated via near retinoscopy (monocular estimation method) for 20-30 seconds each eye. The subject was asked to find the letters of his/her name among a set of 20/80 size letters at 40 cm. An accommodative lag or lead was determined and quantified by plus or minus lens neutralization. Accommodative instability was also noted when a 0.50 diopter or more fluctuation was observed.

Although the data is not relevant to this study, direct ophthalmoscopy was performed on each eye to screen for ocular disease of the media, posterior retina and optic nerve.

For nearpoint phorometric testing a B&L Greens phoropter was used mounted on a portable stand. Lateral and vertical phorias, relative convergence and divergence were measured using a standard 20/20 diamond card at 40 cm. Positive relative accommodation was measured monocularly and binocularly and negative relative accommodation was measured binocularly only using standard 20/20 print at 40 cm. Retinoscopy findings were considered the control lens for near from which the net positive and negative relative accommodative values were calculated from gross values recorded. PRA measurement was stopped when a value of -5.00 diopters gross was attained without blur unless the subject was myopic in which case the test was continued until blur out.

Focusing Facility, the relative ease with which an individual can adjust his/her focusing system to a 2 diopter relative lens induced change in

---

demand was measured at 40 cm using 20/40 (newsprint) size letters. This approximates the accommodative jump required as a student shifts there focus from the chalkboard to print at a nearpoint distance of approximately 20 cm. The subjects were given a "learning period" consisting of 3 successive  $\pm 2.00$  cycles and the time elapsed in clearing the print through each lens was then measured for final data on the 4th and 5th cycles. The time to clear the print based on the ability of the subject to read the 20/30 letters was quantified into three categories, less than 3 seconds, 3-5 seconds, or greater than 5 seconds.

Vergence Facility was measured using the same basic procedure as the focusing facility except the 20/20 diamond card was used as a stimulus. The subject was asked to tell the researcher when the diamond came back into one after a loose prism was placed before the right eye either 8 base in creating a relative divergence demand or 10 base out creating a relative convergence demand at 40 cm. This simulates the quick jump in relative vergence position of the eyes from a 40 cm target distance to approximately 85 cm distance using the 8 base in prism or from 40 cm to approximately 24 cm using the 10 base out prism (figured for an average PD of 60 mm). The time in seconds it took to regain fusion after introduction of the prism was noted on the 4th and 5th trials.

In order to thoroughly evaluate pursuit and saccadic eye movements, both a nonverbal test (NSUCO Oculomotor Test) and a verbal reading test (Developmental Eye Movement Test) were used. It is important to test eye movements in both formats in order to assess the variable of basic phonological coding and speech production in measuring saccadic efficiency (reading eye movements). The DEM also has the additional variable of a crowded visual stimulus that requires selective central attention and peripheral suppression. The DEM may be more diagnostic for an M pathway deficit.<sup>43</sup>

The NSUCO Oculomotor test was designed by W.C. Maples to quantify clinical observations of pursuit and saccadic eye movements.<sup>51</sup> Evaluation of pursuit and saccadic eye movements purely by observation on the part of the experienced clinician is a very valuable assessment tool. Unfortunately, it is a very subjective measure and inter-observer reliability may be poor. The NSUCO Test was designed to create a standard protocol for evaluating and quantifying pursuit and saccadic eye movements in terms of efficiency and motor overflow, accuracy, and sustained visual attention to the task. Quantified data lends itself to a normative scale that has been developed for the test. Since this test is newly published, I will briefly outline the procedure.

The test is easily administered in any setting with the subject standing without benefit of support. No instructions are given regarding head or body movement. Targets are held at approximately 40 cm. For the pursuit portion of the test, the subject is to track binocularly a 1/2 cm colored ball through

four complete 20 cm diameter rotations centered on midline. Two of the rotations are done clockwise and the other two counterclockwise. For the saccadic portion, the subject is asked to shift his attention through 10 cycles between two 1/2 cm colored balls spaced 20 cm apart at eye level. Both pursuits and saccadic eye movements are evaluated for ability to complete all movements (visual attention span), accuracy, and head and body overflow movement. These observations are quantified for normative analysis on a 1-5 scale for each category. For this study, the score sheet given in appendix B of the NSUCO Oculomotor Test Manual was used for ease and reliability of data collection.

The Developmental Eye Movement Test<sup>52</sup> measures saccadic efficiency by having the subject read a series of numbers on a page. The primary measure of saccadic ability is based on the time it takes the subject to complete the test. In order to separate out the variable of verbal automaticity, the test is given in two parts. The first part consists of two separately administered sheets of numbers arranged in two vertical columns. The second part consists of a final sheet of variably spaced numbers arranged in rows. Each part, vertical and horizontal, contain a total of 80 numbers that must be read. Time for each part is adjusted for addition and subtraction errors. The two parts can be compared to give a ratio of horizontal time/vertical time in order to determine if a slow time is really due to poor horizontal efficiency or due to general language production problems. The test is well established and has good normative data. For the purpose of this study, total horizontal time was converted to a standard score for intersubject comparison and the horizontal/vertical ratio was analyzed to determine the relative validity of the horizontal saccadic score.

## **DIAGNOSTIC CRITERIA FOR BINOCULAR AND ACCOMMODATIVE DISORDERS:**

The diagnostic criteria used in this study were adapted from several sources<sup>50,53</sup> using previous studies as a model.<sup>29,30</sup> To maintain objectivity, complaints of blur, asthenopia or diplopia were considered only as additional evidence for each diagnostic entity even though in the clinical setting these complaints would be given more weight. A correlation between near complaints and findings was done separately. Break and recovery cut-off values for fusional vergence used to determine convergence insufficiency, convergence excess, and general binocular dysfunction represent 1.5 standard deviations below the norm according to Morgan.<sup>54</sup> In cases of exotropia at near, these subjects were not given the additional diagnosis of convergence insufficiency.

#### Convergence Insufficiency (378.83)

- receded NPC (break at 4" or greater)
  - exophoria at near greater than distance
  - poor ability to fuse 10 BO prism ( $> 5$  seconds)
- and, at least two of the following:
- reduced near positive fusional vergence ranges (either break  $\leq 12$ , or recovery  $\leq 1$ )
  - low MEM finding ( $< +0.50$ )
  - near stereopsis less than 40"
  - low NRA ( $< 2.00$  D)
  - low accommodative facility clearing  $+2.00$  lens ( $> 3$  seconds)

#### Convergence Excess (378.84)

- esophoria greater at near than distance
  - reduced negative fusional vergence at near (either break  $\leq 15$  and recovery  $\leq 6$ ; or recovery  $< 0$ )
  - slow facility fusing 8 BI prism ( $> 5$  seconds)
- and, at least one of the following:
- low PRA ( $< 2.50$  D)
  - low accommodative facility clearing  $-2.00$  lens ( $\geq 3$  seconds)
  - high MEM finding ( $> +0.50$ )

#### General Binocular Disorder

- reduced positive and negative vergence ranges (either BO  $\leq 12/1$  and BI  $\leq 15/6$ ; or both BO and BI recoveries less than 2)
  - poor vergence facility ( $\geq 3$  seconds on both 10 BO and 8 BI)
- and, at least two of the following:
- low exophoria or esophoria (near phoria between 2 eso and 4 exo)
  - low PRA ( $\leq 3.00$  D) and NRA ( $\leq 1.75$  D)
  - difficulty clearing both plus and minus lenses on accommodative facility testing ( $\geq 3$  seconds to clear both)
  - stereopsis  $< 40''$

#### Vertical Imbalance (378.43)

- vertical phoria  $> 1$

#### Strabismus (Exotropia or Esotropia)

- any constant or intermittent horizontal deviation on the unilateral cover test
- should be accompanied by any of the following:
- reduced stereopsis ( $< 40''$ )
- reduced vergence ranges (BO  $\leq 12/1$  if Exotropia, BI  $\leq 15/6$  if Esotropia)
- low PRA ( $\leq 2.50$  D) or NRA ( $\leq 2.00$  D)

#### Accommodative Insufficiency (367.51)

- low PRA ( $< 2.50$  D)
- difficulty clearing  $-2.00$  lens ( $\geq 3$  seconds)
- and, at least one of the following:
  - reduced near acuity ( $< 20/20$ )
  - high MEM finding ( $> +0.50$ )
  - unstable MEM and retinoscopy findings (fluctuation of .5 D or more)

#### Accommodative Excess or Spasm (367.53)

- low NRA ( $< 2.00$  D)
- difficulty clearing  $+2.00$  lens ( $\geq 3$  seconds)
- low MEM (accommodation measured at or in front of target, plano or minus lens to neutralize)
- may also see unstable MEM or distance retinoscopy

#### Accommodative Infacility (367.9)

- at least 3 seconds to clear both plus and minus 2.00 lenses
- and at least one of the following:
  - low NRA ( $< 2.00$ ) and PRA ( $< 2.50$ )
  - poor vergence facility (at least 3 seconds to fuse both BO and BI)

#### Oculomotor Dysfunctions

General oculomotor dysfunction includes both pursuit and saccadic dysfunction, but for the purpose of this study, it is important to distinguish between the two:

##### Smooth Pursuit Deficiencies (379.58)

- failure of the NSUCO Oculomotor Test in Accuracy and at least one other category (30% failure criterion in Table 11-2 of NSUCO OM Test normative data)

##### Saccadic Eye Movement Deficiencies (379.57)

A combination of the NSUCO OM Test and the DEM were used to establish saccadic deficiency in three different ways. Each criteria set allows for more weight to be placed on one aspect of the testing without disregard to critical diagnostic parameters of the other test.

##### Criteria Set 1: (weights both tests equally)

- failure on accuracy portion of NSUCO Oculomotor Test (30% failure criterion)
  - poor DEM horizontal score (standard score  $\leq 90$ , percentile rank below 25)
  - DEM ratio of at least 1.20
-

Criteria Set 2: (weights DEM more heavily)

- DEM ratio greater than 1:30
  - NSUCO accuracy score of 4 or less
- and at least one of the following:
- failure on an additional aspect of the NSUCO and a DEM horizontal standard score < 100 (50%) or
  - DEM horizontal standard score below 81 (10%)

Criteria Set 3: (weights NSUCO test more heavily)

- score of 2 or less on NSUCO accuracy
- score below 90 (25%) on DEM horizontal
- DEM ratio of at least 1.15 (standard score 100)

## RESULTS

A total of 43 Title One students and 50 controls participated in the study. The average reading level of the Title One students as determined by standardized testing was 1.83 years below grade level. Analysis of the data shows that there are some differences between the control and subject groups if individual findings are compared. Single variable analysis reveals that the two groups differed significantly in nearpoint complaints, acuity, and accommodation. However, a significant and clinically relevant difference is seen between the two groups in terms of percentage of individuals presenting with diagnoses of visual dysfunction.

Table one summarizes the frequency distribution of complaints of both groups. Each case was analyzed to assess whether the complaints matched the findings in order to evaluate the reliability of the population. Children tend to be overly agreeable when asked if they experience visual problems. The grade level readers complained more of distance blur, but less than half of these individuals had findings that justified distance blur. There were fewer individuals in the Title One group complaining of distance blur, but 80% of those matched their findings. In general, a higher percentage of the Title One group had near point complaints, but only near blur was reported at a statistically significant higher rate in the Title One group (>95% confidence level on chi squared analysis). The reliability of double vision complaint was understandably low for both groups since the concept is more difficult to understand. Also, children with good fusional control can make themselves see double by converging or diverging their eyes at near point.

**TABLE 1: COMPLAINTS**

	CONTROLS		TITLE ONE	
	number/ %	*matching/ %	number/ %	* matching/%
Distance Blur	14 / 28%	6 / 42.9%	10 / 23.3%	8 / 80%
Near Blur	14 / 28%	10 / 71.4%	25 / 58.1%	18 / 72%
HA's/discomf.	22 / 44%	16 / 72.7%	23 / 53.5%	18 / 78.2%
Diplopia	14 / 28%	4 / 28.6%	13 / 30%	6 / 46.2%

The frequency distribution of acuities in Table 2 shows us that the Title One group has a greater percentage of individuals with less than 20/20 vision at both distance and near. The poor distance acuity of the few individuals in the Title One group is explained by uncorrected myopia and astigmatism. However, the individuals with reduced near acuity in the Title One group cannot be accounted for by uncorrected hyperopia or astigmatism



alone. There are other factors such as poor accommodation that are contributing to decreased near acuity in these individuals.

**TABLE 2: ACUITY**

**Distance**

	20/20	20/25	20/30	20/40	20/60	20/80	100	200
Controls								
OD	80%	8%	6%	2%	2%	2%	0	0
OS	86%	6%	6%	2%	2%	0	0	0
Title One								
OD	72.1%	4.7%	9.3%	2.3%	2.3%	2.3%	4.7%	2.3%
OS	69.8%	9.3%	4.7%	4.7%	4.7%	0	4.7%	2.3%

**Near**

	20/20	20/30	20/40	20/60	20/80	20/100	20/200
Controls							
OD	88%	12%	0	0	0	0	0
OS	90%	10%	0	0	0	0	0
Title One							
OD	76.7%	13.6%	4.7%	2.3%	0	2.3%	0
OS	79.1%	11.6%	4.7%	2.3%	0	2.3%	0

The control and Title One groups had similar composition of refractive errors. The mean refractive error of both groups fell in the low hyperopia range. Looking at the data in terms of clinically significant uncorrected refractive errors, the only difference seen is a few uncorrected myopes in the Title One group.

**REFRACTIVE ERROR:**

		<u>CONTROL</u>	<u>TITLE ONE</u>
MEAN	OD	+0.56	+0.53
	OS	+0.72	+0.54
Uncorrected hyperopia of 1.00 D or more		20 40%	16 37.2%
Uncorrected myopia of 0.25 D or more		2 4%	5 10%
Uncorrected astigmatism of 0.75 D or more		1 2%	2 4.7%

There were no individuals in either group with uncorrected anisometropia over 0.50 diopter.

Looking at mean phoria, the Title One group measured a slight tendency toward greater exophoria, however this difference is not statistically significant. If we look at the near phoria data in terms of clinically significant outliers, we see that the mean of the Title One group was pushed toward exophoria by a few very highly exophoric individuals, including two subjects that suffered from intermittent exotropia at near. The difference in mean phoria was also affected by less esophores in the Title One group.

#### PHORIA:

	<u>Control</u>	<u>Title One</u>
Mean near phoria	2.2 EXO	4 EXO
Exophores of 10 prism diopters or greater	1 (2%)	5 (11.6%)
Esophores of 4 prism diopters or greater	5 (10%)	3 (7%)

There was also a significant difference between the two groups in terms of the percentage of individuals with low positive relative accommodation. A mean PRA cannot be calculated from the data since the testing was stopped at a value of 5.00 diopters. If we look at the accommodation data in terms of borderline and below normal findings, we see that the Title One group clearly contains significantly more individuals who may not possess enough focusing reserve to sustain nearpoint work. Eight of the fifteen Title One subjects with  $\leq 3.00$  diopters of PRA showed reduced nearpoint acuity ( $< 20/20$  in both eyes). One of these subjects had significant astigmatism accounting for the reduced acuity and two manifested hyperopia of 1.50 diopters. Three of the eleven control subjects with  $\leq 3.00$  diopters of PRA had reduced nearpoint acuity, all of whom had low hyperopic refractive errors.

#### ACCOMMODATION:

	<u>Controls</u>	<u>Title One</u>
Net PRA less than 4.00 D	22 (44%)	23 (53.5%)
Net PRA of 3.00 D or less	11 (22%)	15 (34.9%)
Net PRA of 2.00 D or less	0	8 (18.6%)

The most significant difference between the subject and control groups was determined by case analysis and assignment of appropriate diagnoses based on the criteria outlined previously. Table 3 summarizes this data.

**Table 3: Diagnoses**

	CONTROLS (50)	TITLE ONE (43)	Title One non-ESL (27)	Title One ESL (16)
Accommodative Insufficiency	1 (2%)	6 (14%)	5 (18.5%)	1 (6%)
Accommodative Excess	1 (2%)	1 (2.3%)	1 (3.7%)	0
Accommodative Infacility	1 (2%)	5 (11.6%)	3 (11%)	2 (12.5%)
Convergence Insufficiency	0	4 (9.3%)	3 (11%)	1 (6%)
Convergence Excess	1 (2%)	1 (2.3%)	1 (3.7%)	0
Fusional Dysfunction	0	1 (2.3%)	1 (3.7%)	0
Strabismus	1 (2%) IXT	3 (7%) 1XT, 2 IXT	2 (7.4%)	1 (6%)
Vertical Imbalance	2 (4%)	0	0	0
Smooth Pursuit Deficiency	7 (14%)	10 (23.3%)	5 (18.5%)	5 (31%)
Saccadic Deficiency	6 (12%)	21 (48.8%)	12 (44%)	8 (50%)

The first two columns of Table 3 show the numbers of individuals and percentages of each entire group diagnosed with each near point problem. 16 out of the 43 Title One subjects were ESL students. Such a significant proportion required specific analysis to see if the ESL students have a similar visual composition compared to the rest of the Title One group. Columns three and four allow direct comparison of the Title One subpopulations. It is clear that the ESL subpopulation is not visually distinct from the rest of the Title One group. In fact, a greater percentage of pursuit and saccadic deficiencies were found in the ESL subpopulation.

Chi squared analysis revealed a statistically significant difference (95% confidence level) between the control and Title One subjects for the disorders of accommodative insufficiency, convergence insufficiency, and saccadic deficiency. The difference between the two groups for accommodative infacility was significant at the 90% confidence level. There is also a higher incidence of exotropia, fusional dysfunction and pursuit deficiency in the Title One group, but the proportions are not significant due to small sample size. Of the two vertical imbalance cases seen in the control group, one was concomitant with intermittent exotropia and the other individual had congenital superior oblique paresis with strong central suppression. This latter case required no intervention other than a thorough eye health evaluation.

Another important way to look at the data is in terms of the number of individuals in each group with more than one clinically significant near point visual disorder. These are the individuals who would most likely benefit from treatment with glasses, vision therapy or both. Ten (20%) of the control group manifested significant refractive error in the form of astigmatism or hyperopia of at least 1.00 diopter along with at least one other diagnosis. Twenty-four (56%) of the Title One group manifested the same level of visual impairment. Two (4%) of the control group manifested two or more nearpoint disorders in addition to uncorrected refractive error while 13 (30%) of the the Title One group fell into this category. Children with this degree of visual impairment would definitely benefit from corrective measures.

## Discussion

It is clear from the data in this study that the incidence of nearpoint visual disorders is significantly higher in the Title One reading disabled group. In the single measures of acuity, accommodation, and exophoria, it is the reading disabled individuals that comprise the bottom of the barrel. Even more significant is the higher incidence of nearpoint binocular and oculomotor dysfunction in the reading disabled population and the number of individuals with multiple impairments.

Previous studies looking at specific nearpoint visual disorders in different populations of reading disabled have provided mixed results. Adler and Grant,<sup>28</sup> in their study of visual skills and reading ability in 86 secondary school students, found that there was no significant difference between grade level and poor readers in refractive error or disorders of binocularity. Children reading two or more years below grade level did show a higher incidence of accommodative insufficiency. Adler and Grant also found that children in their study population who were treated for visual disorders with glasses, vision therapy or prisms improved significantly in reading performance as compared to a control group over an eight month period. Letourneau, et al<sup>27</sup> examined 735 school children ages 7-14 for convergence insufficiency. They compared the academic results of 25 convergence insufficient children with those of 251 children with normal convergence amplitude. They found no relationship between academic achievement and convergence insufficiency, although no objective test of reading achievement was employed. Hall and Wick<sup>26</sup> performed a multivariate correlation between vision screening results and reading achievement scores as determined by the Stanford Achievement Test on 111 school children. They found no correlation between any combination of visual skills and reading achievement except amplitude of accommodation for 2nd grade students. Detracting from the significance of this study is the fact that students with strabismus or clinically significant uncorrected

refractive error were excluded. Also, the screening tests performed did not provide the quality of data necessary to produce clinically defined diagnoses of visual dysfunction.

Two previous studies comparing vision and reading ability grouped data into clinically useful diagnostic categories in a format similar to the one presented here. Scheiman, et al<sup>29</sup> performed a visual skills appraisal of individuals identified as Irlen filter candidates. They found that 95% of their study group had at least one significant visual disorder. In their study of fourteen adults participating in a remedial reading program, Helson and Maples<sup>30</sup> found that 100% had at least one visual disorder. The diagnostic criteria used in the present study was very similar to these two studies, the primary difference being that the criteria employed in this study took into account the normative data for the relatively young subject population. Also, these two studies relied entirely on the DEM with a failure criteria based solely on the ratio score to diagnose saccadic dysfunction. Table four provides a summary of the data from these two previous studies for comparison to the present study. Combining the information from these studies provides substantial evidence that the prevalence of nearpoint visual disorders is higher in the reading disabled than the general population.

**TABLE 4:**

Type of Disorder	Scheiman et al	Helson, Maples	Present Study
Binocular	57%	100%	21%
Accommodative	34%	86%	28%
Oculomotor	29%	64%	72%

The developmental optometrist considers nearpoint vision disorders as risk factors affecting reading performance, just as the educator considers factors like language acquisition, home enrichment, and general intelligence. Clearly the Title One group in this study contains not only more individuals with risk factors, but also more individuals with multiple visual risk factors. The more risk factors present, the greater the likelihood of reading failure. For example, if a child is farsighted, he needs to accommodate more to maintain a clear focus on near print. If the child also has accommodative insufficiency, then he may have difficulty compensating for his farsightedness and nearpoint blur results. Add on to this an additional disorder of convergence or oculomotor control and the child now has to try to read print that is blurry and jumps around or splits periodically. If this child is naturally intelligent, comes from a supportive home and has a high level of motivation, he may be able to overcome his visual dysfunction and perform at grade level. However, avoidance behavior or failure to achieve in reading is the more likely outcome in most cases.

The results of this study strongly indicate that the students being served by the Title One reading program in the Northern Willamette Valley are a high risk group for visual problems. By standard clinical judgement, 56% of the Title One students in this study would benefit from treatment of visual dysfunction through glasses, vision therapy or both. It is reasonable to conclude that visual disorders are likely to be playing a significant role in the illiteracy of many Title One students.

## CONCLUSION

The basic reasoning behind the Title One program is sound. Undoubtedly, socioeconomic factors do play a significant role in academic achievement. Reading, however, is a very complex task that is dependent on the visual system to provide clear and sustained sensory input for language processing. Of all learning tasks, reading is the most dependent upon vision. The evidence presented here and in previous studies demonstrates a need for educators to be more aware of the visual dysfunctions that can detract from reading ability, especially when evaluating a student whose academic difficulties are specific to reading. Too often, the primary educator will recognize that a child is a poor visual learner and modify curriculum to provide more auditory and kinesthetic learning opportunities. Unfortunately, secondary and higher education requires more complex and demanding visual learning and academic success becomes increasingly dependent upon adequate visual motor and visual perceptual skills. Studies looking at the visual skills of adolescents and adults demonstrating poor literacy have found a significantly higher prevalence of visual dysfunction than was found in this study of primary school children.<sup>29,30,55,56</sup> This strongly indicates that we need to address the visual deficits of these children rather than working around them at the primary grade levels.

While the educator is in a unique position to detect visual deficiencies, many subtle problems of visual function are only uncovered by specific testing of the developmental optometrist. The study presented here has added to the data base demonstrating the need for a thorough assessment of the visual skills of all reading disabled students. Considering the growing body of research showing that treatment of visual dysfunctions in the reading disabled population produces significant gains in reading fluency and comprehension, it would be sensible look at vision more closely in this special population. It is the goal of the Title One program to provide at risk children with an equal opportunity for learning. Correction of visual disorders should be considered an essential element to achieving this end.

## REFERENCES

1. Suchoff IB. Research on the relationship of vision and reading - what does it mean? *J Learn Disabil* 1981; 14: 573-76.
2. Grisham JD, Simons HD. Refractive error and the reading process: a literature analysis. *J Am Optom Assoc* 1986; 57: 44-55.
3. Garzia RP. Vision and reading. St. Louis: Mosby Year Book, Inc., 1996
4. Simons HD, Grisham JD. Binocular anomalies and reading problems. *J Am Optom Assoc* 1987; 58: 578-87
5. Griffin D, Walton H, Ives U. Saccades as related to reading disorders. *J Learn Disabil* 1974; 7: 310-16.
6. Pavlidis GT. Eye movement differences between dyslexics, normal, and retarded readers while sequentially fixating digits. *Am J Optom & Physiol Optics* 1985; 62:820-32
7. Pavlidis GT. Eye movements in dyslexia: their diagnostic significance. *J Learn Disabil* 1985; 18: 42-50.
8. Duane A. Anomalies of the accommodation, clinically considered. *Arch Ophthalmol* 1916; 45: 124-136.
9. Hoffman LG. Incidence of vision difficulties in children with learning disabilities. *J Am Optom Assoc* 1980; 51: 447-51.
10. Shorr RH, Svagr VB. Relationship of perceptual and visual skills with reading accuracy and comprehension. *J Am Optom Assoc* 1966; 37: 671-77.
11. Coleman HM. Visual perception and reading dysfunction. *J Learn Disabil* 1968; 1: 26-33.
12. Rosofsky A. Optometric visual training - an evaluation. *Opt J Rev Optom* 1974; Vol. III, No. 22.
13. Keogh B. Optometric visual training programs for children with learning disabilities: Review of issues and research. *J Learn Disabil* 1974; 7(4): 219-230.
14. Haddad HM, Isaacs NS, Onghena K, Mazor A. The use of orthoptics in: dyslexia. *Metabolic, Pediatric, and Systemic Ophthalmology* 1982; 6: 129-132.
15. Suchoff IB, Petito T. The efficacy of visual therapy. *J Am Optom Assoc* 1986; 57(2): 119-125.
16. Seiderman AS. Optometric vision therapy - Results of a demonstration project with a learning disabled population. *J Am Optom Assoc* 1980; 51(5): 489-493.
17. Swanson W. Optometric vision therapy - How successful is it in the treatment of learning disorders. *J Learn Disabil* 1972; 5(5): 285-290.
18. Drerby C. "Vision" problems and reading disability: a dilemma for the reading specialist. *The Reading Teacher* 1979; 787-795.
19. Flax N. The eye and learning disabilities. *J Learn Disabil* 1973; 6(5): 328-333.

20. American Association of Ophthalmology. The eye and learning disability. Joint Organizational statement of the American Academy of Pediatrics, American Academy of Ophthalmology and Otolaryngology, American Association of Ophthalmology. Washington D.C.: Am Assoc. of Ophthalm 1970.
  21. Eames TH. Low fusional convergence as a factor in reading disability. Am J Ophthalmol 1934; 15: 709-710.
  22. Eames TH. Comparison of eye conditions among 1000 reading failures, 500 ophthalmic patients, and 150 unselected children. Am J Ophthalmol 1948; 31: 713-717.
  23. Kephart NC. Visual skills and their relationship to school achievement. Am J Ophth 1953; 36: 794-799.
  24. Shearer RV. Eye findings in children with reading difficulties. J Pediatr Ophthalmol 1966; 3: 47-52.
  25. Park GE. Reading difficulty (dyslexia) from the ophthalmic viewpoint. Am J Ophthalmol 1948; 31: 28-34.
  26. Hall PS, Wick BC. The relationship between ocular functions and reading achievement. J Pediatric Ophthalmol and Strab 1991; 28: 17-19.
  27. Letourneau JE. The relationship between convergence insufficiency and school achievement. Am J Optom & Physiol Optics 1979; 56(1): 18-22.
  28. Adler PM, Grant R. Literacy skills and visual anomalies. Optom Today Jan. 1988; 15-16.
  29. Scheiman M, Blasky P, Ciner E, et al. Vision characteristics of individuals identified as Irlen filter candidates. J Amer Optom Assoc, 1990; 61: 600-605.
  30. Helson L, Maples WC. The optometric evaluation of adult females participating in a remedial reading program. J Behav Optom 1994; 5(4): 87-92.
  31. Peters HB, Blum HL, Bettman JW. Vision screening for elementary schools: The Orinda Study. Berkeley: University of California Press, 1959.
  32. Spache GD, Tillman CE. A comparison of the visual profiles of retarded and non-retarded readers. J Devel Reading 1962; 5: 101-109.
  33. Eames TH. A comparison of the ocular characteristics of unselected and reading disability groups. J Educ Res 1932; 25: 211-215.
  34. Simons H, Grisham D. Vision and reading disability: research problems. J Am Optom Assoc 1986; 57: 36-42.
  35. Clark B. Additional data on binocular imbalance and reading. J Educ Psych 1936; 27: 530-538.
  36. Bedwell CH, Grant R, McKeown JR. Visual and ocular control anomalies in relation to reading difficulty. Br J Educ Psychol 1980; 50: 61-70.
  37. Stein J, Fowler S. Occlusion treatment. Optician 1986; 11: 16-22.
  38. Birnbaum P, Birnbaum MH. Binocular coordination as a factor in reading achievement. J Am Optom Assoc 1968; 39: 48-56.
  39. Ludlum WM, Ludlum DE. Effects of prism-induced accommodative convergence stress on reading comprehension test scores. J Am optom Assoc 1988; 59(6): 440-445.
-



40. Ygge, et al. Oculomotor functions in a Swedish population of dyslexic and normally reading children. *Acta Ophthalmologica* 1993; 71: 10-21.
41. Rosenthal JH. The neuropsychopathology of written language. Oakland: Rosenthal 1977.
42. Black, et al. A detailed study of sequential saccadic eye movements for normal and poor-reading children. *Percept Mot Skills* 1984; 59: 423-434.
43. Garzia RP, Sesma MA. Vision and reading I: Neuroanatomy and electrophysiology. *J Optom Vis Dev* 1993; 24: 4-51.
44. De Hirsch K, et al. Predicting reading failure. New York: Harper & Row, 1966.
45. Wesson M. Diagnosis and management of reading dysfunction for the primary care optometrist. *Optom & Vis Science* 1993; 70(5): 357-368.
46. Conference Report to the 103rd Congress of the United States: Improving America's Schools Act; Title One - Amendments to the Elementary and Secondary Education Act of 1965. House of Representatives Report, Sept. 28, 1994.
47. United States Dept of Education. Helping disadvantaged children meet high standards; final rule. *Federal Register*; Vol. 60, No. 127, July 3, 1995.
48. Oregon Dept. of Education. Reading Performance Standards. Office of Assessment and Management, Nov. 1995.
49. Schrier M, Hamakiotas D. School vision screening: A comparison of the results from two school populations of differing socioeconomic composition. *J Optom Vis Devel* 1993; 24: 15-20.
50. Schmitt EP. Guidelines for clinical testing, lens prescribing, and vision care. Santa Ana: Optometric Extension Program Foundation, 1996.
51. Maples WC. NSUCO Oculomotor Test. Santa Ana: Optometric Extension Program Foundation, 1995.
52. Garzia RP, Richman JE, Nicholson SB, et al. A new visual-verbal saccadic test: the Developmental Eye Movement Test (DEM). *J Am Optom Assoc* 1990; 61: 121-35.
53. Goss DA. Ocular accommodation, convergence and fixation disparity: A manual of clinical analysis. Stoneham, MA: Butterworth-Heinemann, 1986.
54. Morgan MW. Analysis of clinical data. *Am J of Optom and Arch of Am Academy of Optom* 1944; 21: 477-491.
55. Johnson R, Zaba J. Examining the link between vision and illiteracy. *J Behav Optom* 1994; 5(2): 41-43.
56. Johnson R, Zaba J. Vision screening of at risk college students. *J Behav Optom* 1995; 6(3): 63-65.

## **APPENDIX**

### **Evaluation forms used in the study**

## VISION SCREENING REPORT

JOHN P. LOWERY, O.D.  
Silver Falls Eyecare  
(503) 873-8619

NAME \_\_\_\_\_

DATE \_\_\_\_\_

AGE \_\_\_\_\_

GENDER \_\_\_\_\_

GRADE \_\_\_\_\_

ETHNICITY \_\_\_\_\_

PRIMARY LANGUAGE SPOKEN AT HOME \_\_\_\_\_

### OCULAR HISTORY:

Glasses/contact lens wear: Presently Past Far Near Full time

Eye injuries, disease, or surgeries \_\_\_\_\_

Blur while reading/distance: never sometimes always

Head or eye pain while reading: never sometimes always

Double vision while reading: never sometimes always

HABITUAL VISUAL ACUITY: FAR OD 20/ OS 20/ NEAR OD 20/ OS 20/

COVER TEST FAR:

NEAR:

NPC:

EOMS:

DEPTH PERCEPTION:

DISTANCE REFRACTION (retinoscopy): OD \_\_\_\_\_ OS \_\_\_\_\_

NEAR RETINOSCOPY (MEM): OD \_\_\_\_\_ OS \_\_\_\_\_

OPHTHALMOSCOPY: OD: Media Macula C/D OS: Media Macula C/D

NEARPOINT PHOROMETRIC TESTING: (through habitual correction)

LATERAL PHORIA \_\_\_\_\_

VERTICAL PHORIA \_\_\_\_\_

RELATIVE CONVERGENCE \_\_\_\_\_ DIVERGENCE \_\_\_\_\_

FOCUSING: PRA: OD \_\_\_\_\_ OS \_\_\_\_\_ OU \_\_\_\_\_ NRA: OU \_\_\_\_\_

FOCUSING FACILITY: (seconds to clear 20/20 print)

+2.00 <3 3-5 >5

-2.00 <3 3-5 >5

VERGENCE FACILITY: (seconds to fusion of 20/20 print)

8 BI <3 3-5 >5

10 BO <3 3-5 >5

NSUCO OCULOMOTOR TEST: Ability Accuracy Head movement Body

Pursuits

Saccades

DEVELOPMENTAL EYE MOVEMENT TEST:

Vertical \_\_\_\_\_ Horizontal \_\_\_\_\_ Ratio \_\_\_\_\_

Summary and Recommendations:

---

---

---

---

---

---

---

---

## APPENDIX B

### NSUCO METHOD OF SCORING SACCADDES AND PURSUITS ABILITY

(Can the patient keep his attention under control to complete five round trips for saccades and two clockwise and then two counterclockwise rotations for pursuits?)

#### SACCADDES

1. Completes less than two round trips
2. Completes two round trips
3. Completes three round trips
4. Completes four round trips
5. Completes five round trips

#### PURSUIITS

1. Cannot complete 1/2 rotation in either the clockwise or counterclockwise direction
2. Completes 1/2 rotation in either direction
3. Completes one rotation in either direction but not two rotations
4. Completes two rotations in one direction but less than two rotations in the other direction
5. Completes two rotations in each direction

#### ACCURACY

Both pursuits and saccades are graded alike.

(Can the patient accurately and consistently fixate so that no noticeable correction is needed in the case of saccades or tracking the target so that no noticeable refixation is needed when doing pursuits?)

#### SACCADDES

1. Large over- or undershooting is noted one or more times
2. Moderate over- or undershooting noted one or more times
3. Constant slight over- or undershooting noted (greater than 50% of the time)
4. Intermittent slight over- or undershooting noted (less than 50% of the time)
5. No over- or undershooting noted

#### PURSUIITS

1. Refixations more than 10 times
2. Refixations five to 10 times
3. Refixations three or four times
4. Refixation two times or less
5. No refixations

#### HEAD AND BODY MOVEMENTS

(Can the patient accomplish the saccade or pursuit test without moving his head or body? Both saccade and pursuit scoring use the same criteria for this aspect of the testing.)

1. Large movement of the head (body) at any time
2. Moderate movement of the head (body) at any time
3. Consistent slight movement of the head (body) (greater than 50% of the time)
4. Intermittent slight movement of the head (body) (less than 50% of the time)
5. No movement of the head (body)

#### References

1. Maples WC. A study of normal pursuit and saccade function. (Mid-America Vision Conference, 1983: 128-40.
2. Maples WC, Ficklin TW. Interrater and test-retest reliability of pursuits and saccades. *J Am Optom Assoc* 1988; 59: 549-52.
3. Maples WC, Ficklin TW. Test-retest reliability of the King-Devick and the NSUCO oculomotor test. *Behav Optom (Austral)* 1991; 3:209-14.
4. Maples WC, Atchley J, Ficklin TW. Northeastern State University College of Optometry's Oculomotor Norms. *J Behav Optom* 1992; 3: 143-50.

# FORM SCORESHEET

NAME \_\_\_\_\_ DOB \_\_\_\_\_ AGE \_\_\_\_\_ GRADE \_\_\_\_\_

ARTICULATION PRE-TEST    Y    N                      NUMBER KNOWLEDGE PRE-TEST    Y    N

/ = substitution error  
a = addition error

o = omission error  
< or > = transposition error

TEST A

TEST B

TEST C

3	4	6	7	3	7	5	9	8
7	5	3	9	2	5	7	4	6
5	2	2	3	1	4	7	6	3
9	1	9	9	7	9	3	9	2
8	7	1	2	4	5	2	1	7
2	5	7	1	5	3	7	4	8
5	3	4	4	7	4	6	5	2
7	7	6	7	9	2	3	6	4
4	4	5	6	6	3	2	9	1
6	8	2	3	7	4	6	5	2
1	7	5	2	5	3	7	4	8
4	4	3	5	4	5	2	1	7
7	6	7	7	7	9	3	9	2
6	5	4	4	1	4	7	6	3
3	2	8	6	2	5	7	4	6
7	9	4	3	3	7	5	9	8
9	2	5	7	TIME: _____ sec _____ s errors    _____ o errors _____ a errors    _____ t errors ADJ TIME = TIME $\times \frac{80}{(80 - o + a)}$				
3	3	2	5					
9	6	1	9					
2	4	7	8					

\_\_\_\_\_ sec

\_\_\_\_\_ sec

TOTAL TIME: \_\_\_\_\_ sec

ADJ TIME: \_\_\_\_\_ sec

ERRORS: \_\_\_\_\_

ADJ TIME = \_\_\_\_\_ sec

TOTAL ERRORS (s + o + a + t) = \_\_\_\_\_

RATIO =  $\frac{\text{HORIZONTAL ADJ TIME}}{\text{VERTICAL ADJ TIME}}$  = \_\_\_\_\_